Facial Contouring by Targeted Restoration of Facial Fat Compartment Volume: The Midface

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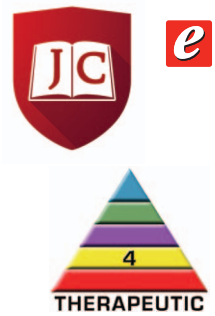

Background: Recent anatomical findings have suggested that facial fat distribution is complex and changes with age. Here, the authors developed a grafting technique based on the physiologic distribution and volume changes of facial fat compartments to achieve a youthful and natural-appearing face.
Methods: Forty cadaveric hemifaces were used for the dissection of fat compartments and neurovascular structures in the midface area. Seventy-eight patients were treated for cheek atrophy using the authors' targeted restoration of midface fat compartment volume. The outcome was evaluated by a two-dimensional assessment, malar lipoatrophy assessment, and a satisfaction survey.
Results: The medial and lateral parts of the deep medial cheek fat compartment were separated by a septum arising from the lateral border of the levator anguli oris muscle. The angular vein traveled between the deep medial cheek fat compartment and the buccal fat pad, 12 mm from the maxilla. A total volume of 29.3 ml of fat was grafted per cheek for each patient. A 12-month follow-up revealed an average volume augmentation rate of 27.1 percent. Pleasing and elevated anterior projection of the cheek and ameliorated nasolabial groove were still obvious by 12 months after the procedure. In total, 95.2 percent of the patients were satisfied with their results.
Conclusions: The present study provides the anatomical and clinical basis for the concept of compartmentally based fat grafting. It allows for the restoration of facial fat volume close to the physiologic state. With this procedure, a natural and youthful facial contour could be rebuilt with a high satisfaction rate. (*Plast. Reconstr. Surg.* 139: 563, 2017.)
CLINICAL QUESTION/LEVEL OF EVIDENCE: Therapeutic, IV.

Facial volume loss in both bony and soft tissues results in hollowness and skin ptosis, which leads to concave facial contour and a deepened nasolabial fold and midcheek groove, conveying a tired and exhausted appearance.[1] Autologous fat grafting has become well accepted for facial rejuvenation by both physicians and patients because of the long-lasting effect and safety profile.[2,3] Thus far, multiple techniques have been suggested to optimize fat grafting, such as structural fat grafting (Coleman technique), the 3M3L technique, and nanofat grafting.[4–7]

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With the pioneering works by Rohrich and colleagues and the growing number of studies on facial fat distribution, we now understand that facial fat is highly compartmented and not a uniform continuous structure.[8–10] Multiple layers of fat compartments, including both superficial and deep fat compartments, can be identified in the temporal and midcheek area.[11,12] These fat compartments play distinct roles in defining the facial

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contour and change differently during aging. Therefore, this should be accounted for during facial contouring by fat grafting to avoid a universally augmented balloon-like face.[13,14] Thus, it is necessary to develop a suitable technique for autologous fat grafting that will allow surgeons to restore volume loss while taking into account the physiologic distribution and changes of different fat compartments during aging to rebuild a youthful and natural-appearing face.

Thus far, there is no consensus in the literature regarding the grafting technique and the injection site.[15–17] In this study, we propose the concept of target volume restoration for cheek fat compartments, by which fat is injected according to the physiologic pattern of fat distribution in the youthful face in a compartment-specific manner.

MATERIALS AND METHODS

Facial Fat Compartment Dissection

Twenty formaldehyde-fixed cadavers were obtained from the Willed Body Program at Shanghai Jiao Tong University School of Medicine. In 40 hemifaces from 20 formaldehyde-fixed cadavers, the ligaments and fascia that constitute boundaries for the superficial and deep fat compartments were identified. The facial artery and angular vein were dissected and measured for their distance to the maxilla.

Clinical Study

Patients

A total of 78 healthy female patients undergoing facial fat grafting from January of 2010 to January of 2014 were included in the present study (Table 1). The study was approved by the institutional review board. Each patient was fully informed regarding the procedure and the aim of the study. (**See Figure, Supplemental Digital Content 1**, which shows patient data and surgical technique, ***http://links.lww.com/PRS/C41***.)

Surgical Technique

Fat was collected by liposuction performed on the abdomen or thigh region using the superwet technique with a 16-gauge cannula attached to a 20-ml syringe. A paraoral commissure incision was made on the lip mucosa 1 to 2 mm adjacent to the oral commissure to avoid any unwanted scar formation. [**See Figure, Supplemental Digital Content 2**, which shows the paraoral commissure incision. The incision was made at the oral mucosa, 1 to 2 mm adjacent to but not exactly at the oral commissure to avoid any unwanted scar formation. From here, a cannula was placed beneath the oral mucosa, in the muscle, or subcutaneously in the first place to ensure accurate placement of fat in different layers in subsequent procedures. The schematic drawing indicates the paraoral commissure injection site (*red dot*), ***http://links.lww.com/PRS/C42.***] From here, an 18-gauge cannula connected to a 1-ml syringe was accurately placed beneath the lip mucosa or subcutaneously in the very beginning as required in subsequent procedures.

Table 1. Demographic and Follow-Up Data for All Patients Undergoing Fat Grafting

Characteristics	Mean ± SD	Range
Age, yr	35.1 ± 11.2	18–53
Body weight, kg	55.2 ± 8.3	43–77
Height, cm	163.7 ± 7.9	152–179
BMI, kg/m^2	19.9 ± 2.5	18.0–27.1
Total follow-up time, mo	16.3 ± 4.1	12–27

BMI, body mass index.

Fat Placement in the Deep Fat Compartment. Autologous fat was placed in the medial part of the deep medial cheek fat compartment by advancing the cannula between the mucosa and the orbicularis oris muscle. The root of the canine tooth was used as a bony marker to approach the medial part of the deep medial cheek fat compartment. The lateral part of the deep medial cheek fat compartment was approached by advancing the cannula in the same layer with the guidance of the first molar tooth and was advanced close to the maxilla. The medial part of the suborbicularis orbital fat compartment was also approached by advancing the cannula in this trajectory in a line connecting the first molar and the lateral limbus of the ipsilateral cornea. Special attention was paid to avoid advancing the cannula too close to the maxilla when the cannula was around the level of the nasal ala. From this incision, the cannula was directed laterally to the superior part of the buccal fat pad from the superoanterior quadrant of the medial wall of the buccal fat pad by advancing the cannula close to the maxilla. For fat placement in the deep cheek fat compartments, the following sequence is recommended: (1) medial part of the deep medial cheek fat compartment; (2) medial part of the sub–orbicularis oculi fat compartment; (3) lateral part of the deep medial cheek fat compartment; (4) lateral part of the nasal base; (5) upper lip in the submucosa layer; and (6) superior part of the buccal fat pad (Fig. 1). [**See Figure, Supplemental Digital Content 3**, which shows a schematic view of compartment-based fat

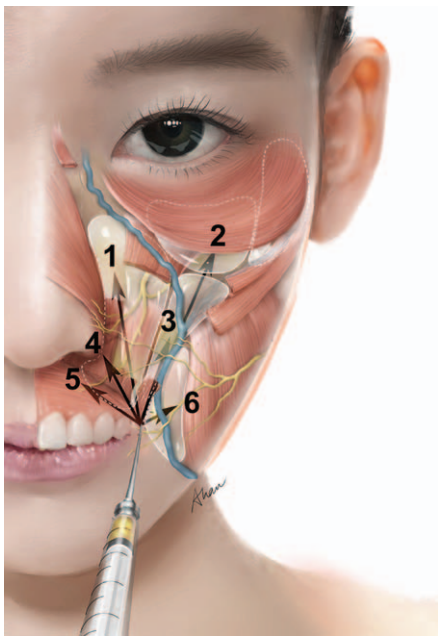

Fig. 1. Trajectory and sequence for deep fat compartment filtration. For fat placement in the deep cheek fat compartments, a specific sequence of fat placement is recommended: *1*, medial part of the deep medial cheek fat compartment; *2*, medial part of the sub–orbicularis oculi fat compartment; *3*, lateral part of the deep medial cheek fat compartment; *4*, lateral part of the nasal base; *5*, upper lip in the submucosa layer; *6*, superior part of the buccal fat pad. (Permission granted for publication from the painter, © Zhou Shuyang.)

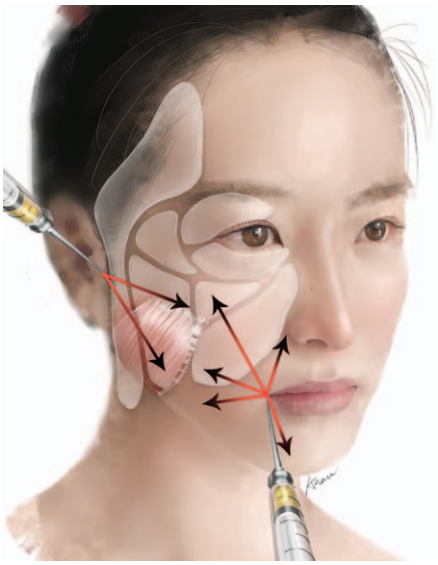

Fig. 2. Trajectory and sequence for superficial fat compartment infiltration through a paraoral commissure incision and an intraearlobe incision. The following sequence is recommended. First, direct the cannula laterally to approximately 1 cm lateral to the oral commissure, and turn upward toward the most prominent point of the zygoma and inject fat along the trajectory while withdrawing the cannula to create the upper half of the lateral border of the golden triangle (medial cheek fat compartment and nasolabial fat compartment). Second, direct the cannula laterally to approximately 1 cm lateral to the oral commissure and turn upward toward the mental tubercle and inject fat along the trajectory while withdrawing the cannula to create the lower half of the lateral border of the golden triangle. Third, direct the cannula to the nasolabial fat compartment and the medial cheek fat compartment medial and lateral to the lateral border of the golden triangle to create a smooth transition. Fourth, direct the cannula deep and along the nasolabial fold when necessary. For augmentation of the middle and lateral cheek fat compartments, another incision in the sideburn could be used as a complement to avoid any unwanted injury to the blood vessels or nerves in the masseteric ligament. (Permission granted for publication from the painter, © Zhou Shuyang.)

grafting. (*Above, left*) Incision at the oral commissure; (*above, right*) defining injection layer; (*second row, left*) cannula advancement submucosally; (*second row, right*) fat grafting into the sub–orbicularis oris fat; (*third row, left*) fat grafting into the lateral part of the deep cheek fat compartment; (*third row, right*) fat grafting into the upper half of the medial part of the deep cheek fat compartment; (*below*) fat grafting into the lower half of the medial part of the deep cheek fat compartment, ***http://links.lww.com/PRS/C43.***]

Fat Placement in the Superficial Fat Compartment. For fat placement in the superficial fat compartments through the paraoral commissure incision, the following sequence is recommended: (1) superior half of the medial cheek fat compartment below the lid-cheek groove; (2) superior part of the nasolabial fat compartment below the mid-cheek groove; (3) superior part of the nasolabial fat compartment below the tear trough; and (4) below the nasolabial fold when necessary (Fig. 2).

For augmentation of the middle and lateral cheek fat compartments, the fat was placed by directing the cannula to the lower one-third of the masseteric ligament where the fibrous structure is weak. Alternatively, another incision in the sideburn was used to avoid any unwanted injury to the blood vessels or nerves in the masseteric ligament (Fig. 2).

Outcome Assessment

All patients were evaluated for malar lipoatrophy grade (Table 2) before surgery and 12 months after the last procedure. The quantitative cheek correction rate was assessed, and a satisfaction survey was conducted 1 year after the last operation.

Quantitative assessment of the cheek hollowing corrective rate was based on two-dimensional facial analysis using frontal photography. [**See Figure, Supplemental Digital Content 4**, which

Table 2. Malar Lipoatrophy Classification

Grade	Manifestation
1	Mild flattening or shadowing of the malar regions
2	Intermediate point between grade 1 and grade 3
3	Moderate concavity of the malar regions; prominence of bony landmarks; may have visibility of underlying musculature
4	Intermediate point between grade 3 and grade 5
5	Severe indentation of the malar regions; severe prominence of bony landmarks; clear visibility of underlying musculature

shows the two-dimensional facial analysis for the quantitative assessment of the cheek concavity corrective rate. Frontal views on preoperative and postoperative photographs were standardized by Adobe Photoshop software (Adobe Systems, Inc., San Jose, Calif.) to locate the two lateral canthi on the same horizontal line. The *x* and *y* axes (*green*) are horizontal and vertical lines passing through the bilateral medial canthus and the lateral limbus of the pupil. The most projected lines of bilateral cheeks were marked with a curvilinear line (*red*). The areas formed by the *x* and *y* axes and the curvilinear line were measured and adjusted with the inter–medial canthus distance by Image Process Plus (Media Cybernetics, Inc., Rockville, Md.). The adjusted areas before and 1 year after surgery were compared as a reflection of volume change of the cheek area. The cheek hollowing corrective rate was assessed quantitatively by calculating the formula (postoperative area − preoperative area)/preoperative area and is presented as a percentage, ***http://links.lww.com/PRS/C44.***] Three-dimensional laser surface scanning images were collected using a Konica Minolta Vivid 910 (without the rotating stage set) and Polygen Editing Tools version 2.21 (Konica Minolta, Tokyo, Japan) as described previously. Images taken before and 1 year after the procedure were overlapped to compare the profile changes according to several selected reference points that would not be altered because of treatment, such as the medial canthus, lateral canthus, tragus, and oral commissure. The discrepancy between these two images was calculated objectively, and a colored hypsographic image was obtained.

A patient satisfaction survey was completed by the patients, the plastic surgeons, and independent investigators of nonmedical background by comparison of preoperative and postoperative photographs as described previously. The degree of improvement was evaluated by all three groups and was classified as fully satisfactory (facial contour remarkably improved), satisfactory (facial contour noticeably improved), or unsatisfactory (facial contour not noticeably improved).

RESULTS

Deep Medial Cheek Fat Compartment

The deep medial cheek fat compartment was separated into medial and lateral parts by a fascia arising from the lateral border of the levator anguli oris (Fig. 3, *above, left*). The medial part of the deep medial cheek fat compartment and Ristow space were located above the canine and first premolar teeth. The lateral part of the deep medial cheek fat compartment was located between the first premolar and the first molar teeth, adjacent to the medial part of the deep sub–orbicularis oculi fat compartment superiorly (Fig. 3, *above, left*). [**See Figure, Supplemental Digital Content 5**, which shows the deep medial cheek fat compartment and nerves traveling in the compartment. The deep medial cheek fat compartment lies between the maxilla and the levator labii superioris and the zygomaticus minor (*above, left*). It is bounded medially by the lateral wall of the nose, laterally by the zygomaticus major and the medial wall of the buccal fat pad, and superiorly by the oblique line of the maxilla below the orbit where the levator labii superioris arises. Inferiorly, the fat extends beyond the nasolabial fold to below the orbicularis oris. The infraorbital nerve and vessels mainly travel in the deep part of the fat compartment (*above, right*). The Ristow space was found between the superior part of the medial part of the deep medial cheek fat compartment and the maxilla, immediately below the infraorbital foramen. The buccal branches of the facial nerve subdivide and interweave in the superficial layer of the deep medial cheek fat compartment and innervate adjacent mimic muscle by heading superiorly, inferiorly, medially. and superficially (*below*), ***http://links.lww.com/PRS/C45.***]

Facial Artery and Vein

The facial artery was found to bifurcate into two major branches in eight of the 40 hemifaces, with one traveling along the usual course and the other accompanying the angular vein. In this case, the accompanying facial artery ran superficial to, instead of beneath, the facial vein (Fig. 3, *above, right*). The angular vein was found to run in the superficial part of the septum separating the lateral part of the deep medial cheek fat compartment and the buccal fat pad, 12 ± 4.3 mm from

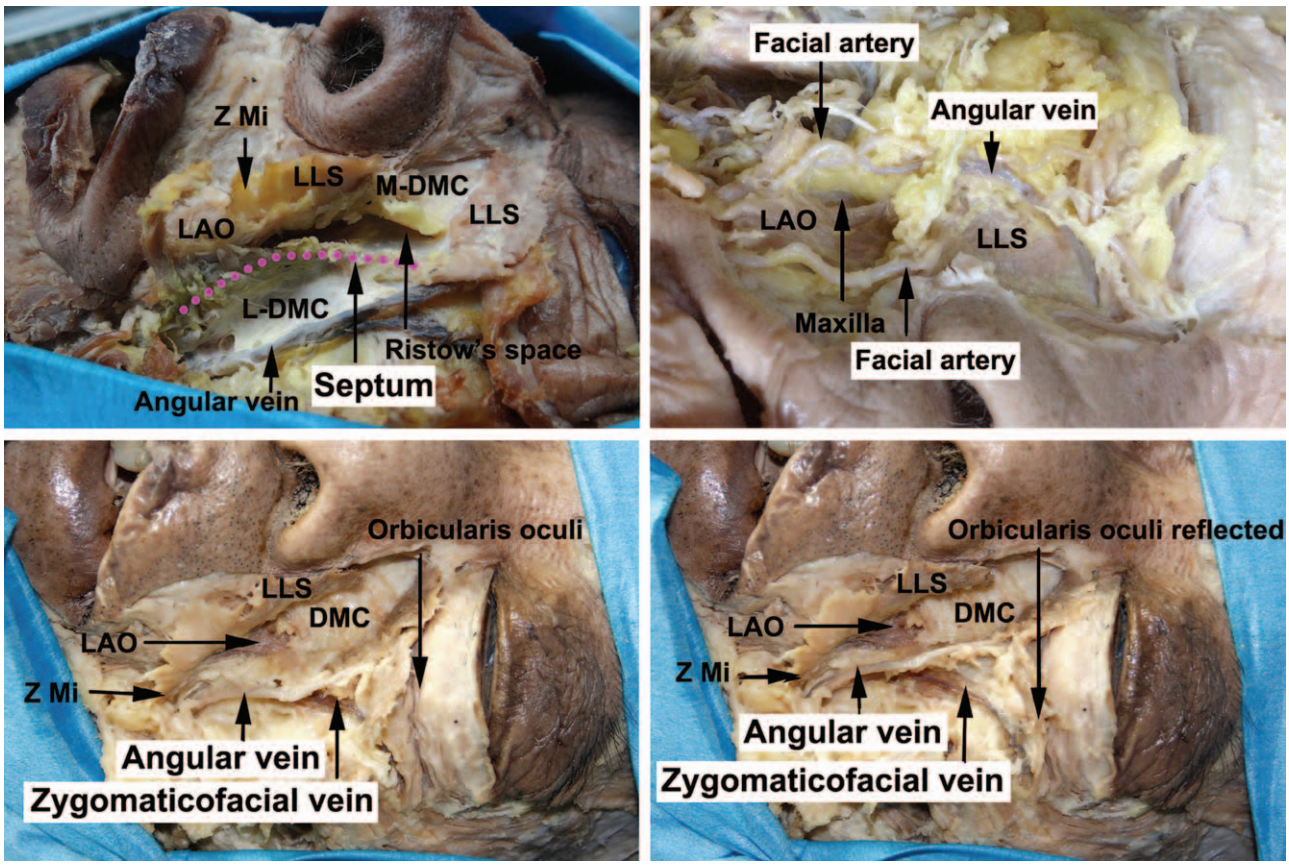

Fig. 3. Boundary between the medial and lateral parts of the deep medial cheek fat compartment and important vessels in the cheek area. The medial and lateral parts of the deep medial cheek fat compartment are separated by a fascia (*purple dashed line*) arising from the lateral border of the levator anguli oris (*above*, *left*). In several cases, the facial artery bifurcates into two branches, with one accompanying the facial vein, which travels 12 mm from the maxilla (*above*, *right*). The angular vein collects a major contributing vein at the level of the origin of the levator anguli oris or the nasal ala, the zygomaticofacial vein (*below*, *left*), which travels close to the periosteum of the maxilla (*below*, *right*). *LLS*, levator labii superioris; *LAO*, levator anguli oris; *M-DMC*, medial part of the deep medial cheek fat compartment; *L-DMC*, lateral part of the deep medial cheek fat compartment; *Z Mi*, zygomaticus minor.

the maxilla (Fig. 3, *above*, *right*). The zygomaticofacial vein drained into the facial vein at around the level of the nasal ala, traveling along the lateral border of the medial part of the suborbicularis orbital fat compartment and close to the periosteum (Fig. 3, *below*).

Clinical Study

Among the 78 patients included in the study, 32 patients were injected in the cheek area only, and 46 patients received injections in both cheek and temporal areas. One to three procedures were performed per patient, with a mean interval of 3.9 months between the two subsequent procedures and a mean total volume of 29.3 ml for the cheek area (Table 3).

The curvilinear line on the anterior view and the three-quarters view became smoother and less concave 12 months postoperatively (Figs. 4 and 5). A pleasing and elevated anterior projection of the cheek and ameliorated nasolabial groove were still obvious by 12 months after the procedure (Fig. 6). The average cheek hollowing augmentation rate was 27.1 percent at 12 months after the last operation (Table 3). Malar lipoatrophy grading scores decreased from 3.3 preoperatively to 1.0 postoperatively. (**See Figure, Supplemental Digital Content 6,** which shows malar lipoatrophy grading before and 12 months after the last procedure, ***http://links.lww.com/PRS/C46***.) The patients reported a satisfaction rate of 76.3 percent in this series, with 18.9 percent of the patients reporting

Table 3. Operative Data for All Patients with Fat Grafting

Characteristics	Mean ± SD	Range
Operation frequency	2.2 ± 0.7	1–3
Procedure interval, mo	3.9 ± 0.9	3.0–6.0
Total grafted fat volume, ml	29.3 ± 9.7	15.0–47.0
Augmentation rate at 12 mo, %	27.1 ± 3.6	21.7–32.3

Fig. 4. Preoperative (*left*) and 12-month postoperative (*right*) photographs after fat grafting in the midface of a 23-year-old woman. The concavity in the anterior and lateral cheek was obvious for her age (*red arrows*).

mostly satisfactory and 4.8 percent reporting unsatisfactory. The results according to three different groups of evaluators are compared and summarized. (**See Figure, Supplemental Digital Content 7**, which shows the patient satisfaction rate 12 months after the last operation evaluated by patients, surgeons, and laypersons, ***http://links.lww.com/PRS/C47***.)

DISCUSSION

Volume restoration by autologous fat grafting has been proven to be a well-accepted and efficient way of rebuilding a youthful face. A successful facial rejuvenation by autologous fat grafting should take into consideration both aesthetic and physiologic characteristics of facial fat distribution to avoid an unexpected and universally augmented balloon-like face after the procedure.

The connection between the most prominent point of the cheek bone and the mental tubercle forms a youthful anterior projection, constituting a characteristic youthful golden facial triangle with smooth transition between different facial subunits. Volume loss in facial fat not only resulted in compartmented facial topography, deepened grooves, and redundancy of facial skin, but also caused a flattened, even concaved facial contour, which made the face appear even wider

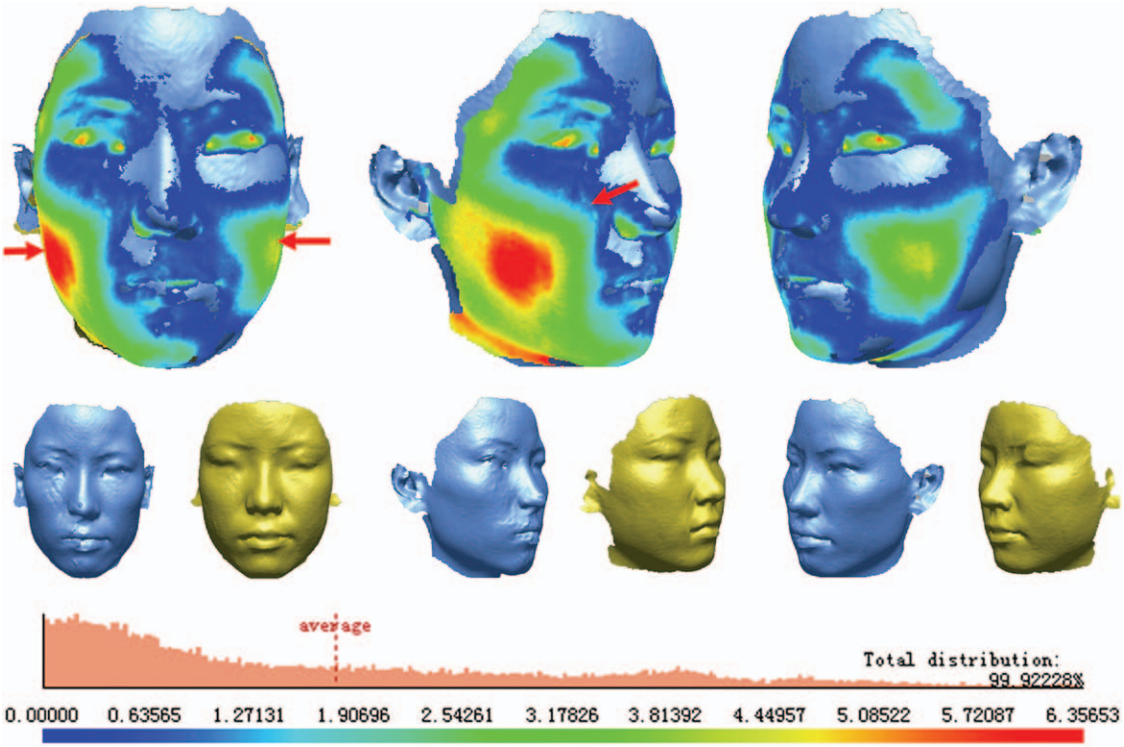

Fig. 5. Three-dimensional scans of the facial topography before (*blue*) and 12 months after (*yellow*) fat grafting. The colors in the different facial areas represent depth variation. *Red arrows* highlight the concavity of the anterior and lateral cheek. Fat was placed in the medial and lateral parts of the deep medial cheek fat compartment, with blending in the nasolabial and medial cheek fat compartments for the anterior cheek concavity. The middle and lateral cheek fat compartments were augmented to adjust the lateral cheek concavity. A significant increase in volume was noted on the three-dimensional scanning images in the subzygomatic area of the lateral cheek and the anterior cheek area (*green*, *yellow*, and *red zones*).

despite volume loss. Studies on facial fat distribution suggest that the volume ratio of superficial to deep cheek fat is almost 1:1 in the cheek area,[18] and with the evolving understanding of facial fat distribution, we now realize that multiple planes and multiple fat compartments can be identified in the cheek. Volume loss during aging involves both deep and superficial fat compartments, which contribute differently to facial contour.[13,14] Although both deep and superficial fat compartments lose volume during aging, the situation is much more complex with regard to the superficial fat compartments, which involve not only volume loss but also downward migration, resulting in deepened facial grooves such as the nasolabial groove, tear trough groove, and midcheek groove because of volume differences in adjacent superficial fat compartments. Moreover, volume loss in the deep cheek fat compartments will cause skin redundancy and ptosis and aggravate facial grooves. Thus, a comprehensive injection scheme should be tailored to create a youthful facial contour and efface grooves and lines.

Therefore, our fat grafting strategy is designed with the aim of fat placement in a multiplane and compartment-specific manner to achieve a state close to the physiologic fat distribution of a youthful face. The paraoral commissure incision is chosen because of its advantages of hidden location and accessibility to different layers. From here, the cannula can be advanced subcutaneously or submucosally as needed in the first place. Considering the changes of the deep and superficial fat compartments caused by aging and their physiologic function in constructing facial contour, a deep-to-superficial injection sequence is suggested.

The deep fat compartments support the superficial malar fat from beneath, the fullness of which is regarded as characteristic of a youthful cheek. In our study, we found that the lateral part of the deep medial cheek fat compartment is located beneath the zygomaticus major and supports this muscle together with the buccal fat pad from beneath; this explains why filling of this compartment recreates the youthful anterior projection, as

Fig. 6. Preoperative (*left*) and 24-month postoperative (*right*) photographs after fat grafting in the midface of a 45-year-old woman. A pleasing and elevated anterior projection could be observed 1 year after surgery (*center*, *right*). The depth and length of the nasolabial fold was also ameliorated (*below*, *right*).

the zygomaticus major constitutes the lateral border of the youthful golden triangle. We also found that by adopting the paraoral commissure incision and advancing the cannula submucosally, the medial part of the deep medial cheek fat compartment and lateral part of the deep medial cheek fat compartment were accessed precisely along the upper canine and first molar teeth. These are helpful bony markers enabling the reproducibility of the procedure. In addition, because of the adjacency of the lateral and medial parts of the sub–orbicularis oculi fat compartment, the fat could be

placed in both compartments by upward advancement in a vertical line through the first molar tooth. The sequence for deep fat augmentation was designed to first supplement the volume loss in the upper part of the deep fat compartments. This would improve the skin ptosis caused by volume loss and is very likely to be helpful for the effacement of the nasolabial groove and the tear trough groove. Injection into the medial part of the suborbicularis orbital fat compartment helps to rebuild a youthful cheek bone, and the volume gain helps to efface the nasolabial groove and also improve the midcheek groove. Additional fat injections may be performed into the nasal base to create a smooth transition between the two regions and also to allow for improvement of the deepened nasolabial groove. Through deep fat volume augmentation, our 1-year follow-up cases suggested a lasting effect on facial contouring. Meanwhile, deep fat grafting also exerted a long-term effect on the effacement of the nasolabial fold. Cannula advancement should follow a resistance-free or low-resistance principle in the deep fat compartments. The cannula should be advanced with the guidance of the maxilla, but not too close to the bone, because the angular vein travels 1 cm from the maxilla, and the zygomaticofacial vein travels along the periosteum.

A cannula placed through a paraoral commissure incision can be advanced to almost all superficial fat compartments in the middle and lower face because of the great flexibility and mobility of the lip tissue. Therefore, the lateral border of the golden triangle connecting the most prominent point of the zygoma and the mental tubercle can be reinforced by fat placement in the superior half of the medial cheek fat compartment, the lateral part of the nasolabial fat compartment, the medial part of the inferior jowl fat, and the lateral part of the labiomandibular fat compartment. Together with deep fat injection, a youthful and more vivid facial contour can be rebuilt, creating a visually narrower and more delicate facial contour because of the reflection of light, despite the augmented volume in both deep and superficial compartments. This may be desirable in men, but it might result in a masculine facial contour in female patients, who will require additional fat grafting in the superficial fat compartments to create a smoother transition and a softer facial contour. Obstacles have been encountered when approaching the middle and lateral cheek compartments.[19,20] Our anatomical findings suggest that the cannula was blocked by the upper half of the masseteric ligament, where numerous perforating vessels reside. [**See Figure, Supplemental Digital Content 8,** which shows the masseteric cutaneous ligament. The masseteric cutaneous ligament arises from the anterior border of the masseter (*left*), presenting a barrier to cannula advancement in the superficial fat compartment. A major hindrance was encountered in the upper part of the ligament, where the fibrous structure is strong and many perforating vessels reside in the ligament (*right*). The ligament is the weakest in the lower one-third, allowing the passage of the cannula from this area with little force, ***http://links.lww.com/PRS/C48***.] Forced advancement of the cannula through the ligament can be risky. An intrasideburn incision would be a helpful alternative for reaching the middle and lateral cheek fat compartments. The total volume for each injection varies greatly from patient to patient, ranging from 4 to 25 cc per cheek, depending on the age and original facial contour of the patient.

We understand that there are still limitations of this study, as it displays the surgical technique and clinical outcome of only one technique. There are still many unanswered questions with regard to the comparison of injection volume, survival rate, and long-term contour changes between the current technique and other techniques. Longer studies in a larger patient population are needed to draw definitive conclusions about the long-term performance of the compartment-specific technique in facial contouring.

CONCLUSIONS

The present study provides the anatomical and clinical basis for compartmentally based facial fat grafting. This technique takes into account the anatomical distribution of the facial fat compartments and their changes with aging. It allows for target restoration of facial fat volume close to that of a youthful face. A natural and youthful facial contour can be rebuilt with a high satisfaction rate using a paraoral commissure incision and following a deep-to-superficial sequence in a compartment-specific manner. A comparative study of the conventional technique versus compartmentally based grafting would be helpful to gain a deeper understanding of facial fat grafting and to optimize the procedure.

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PATIENT CONSENT

Patients provided written consent for the use of their images.

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